# Zeebrugge Model

*wave run-up under simulated prototype storms*

Sclütter, Flemming ; Frigaard, Peter; Liu, Zhou

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REPORT

# Zeebrugge model: Wave run-up under simulated prototype storms

Flemming Schlütter
Peter Frigaard
Zhou Liu

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**HYDRAULICS & COASTAL ENGINEERING LABORATORY**
AALBORG UNIVERSITY
DEPARTMENT OF CIVIL ENGINEERING
SOHNGAARDSHOLMSVEJ 57 DK-9000 AALBORG DENMARK
TELEPHONE +45 96 35 80 80 TELEFAX +45 98 14 25 55

## *Introduction*

This report presents the model test results on wave run-up on the Zeebrugge breakwater under the simulated prototype storms. The model test was performed in January 2000 at the Hydraulics & Coastal Engineering Laboratory, Aalborg University. The detailed description of the model is given in Schlutter et al (1999).

The only possibility to make comparisons between the prototype, the model 1:30 at FH and the model 1:40 at AAU is through the recorded prototype storms. The five recorded prototype storms has been modelled in the laboratory both at FH and AAU. Some of the obtained results from FH is shown in the report of the Bremen workshop (October 1999).

## *Generation method*

The five storm sessions were reproduced in the laboratory. This was done by analysing the time series by FFT, thereby producing spectra. The wave generation software (PROFWACO) was subsequently modified so it was possible to read a spectrum from a file.

The storms were generated at the correct water depths and repeated until good correspondance between measured wave heights ($H_{m0}$) in the model and in prototype was achieved.

## *Results*

The method of reproducing the waves in the laboratory does not ensure that the spectra are completely the same. A comparison between the spectra can be seen in figure 1 to 5.

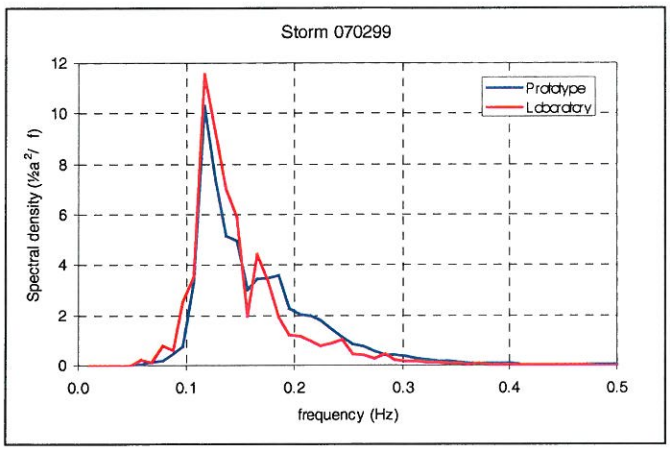


*Figure 1: Spectra from storm 070299.*

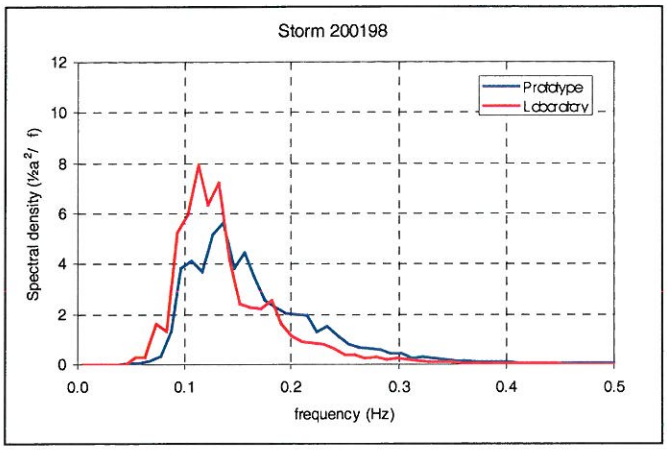


*Figure 2: Spectra from storm 200198.*

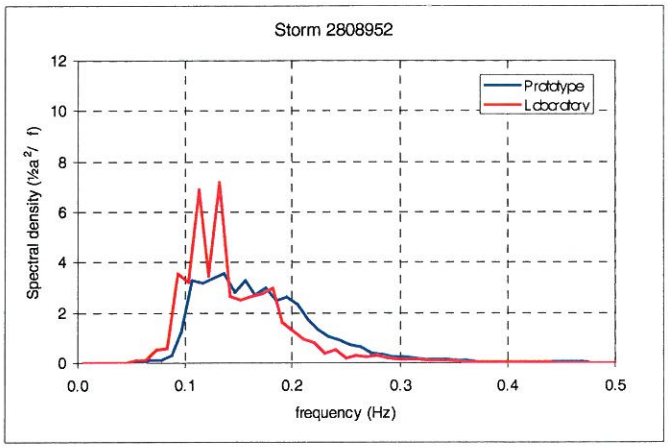


*Figure 3: Spectra from storm 2808952.*

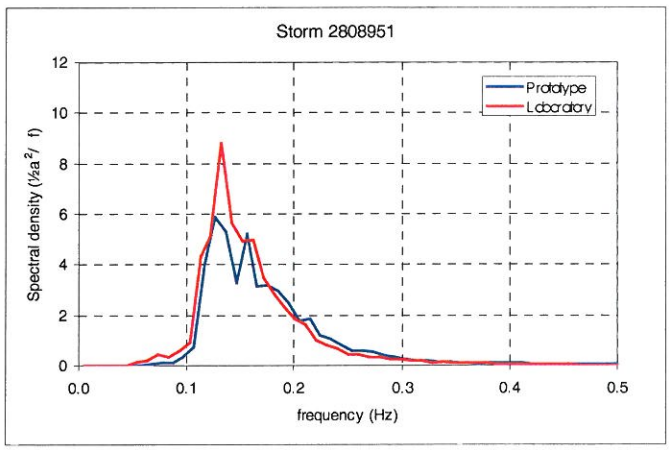


*Figure 4: Spectra from storm 2808951.*

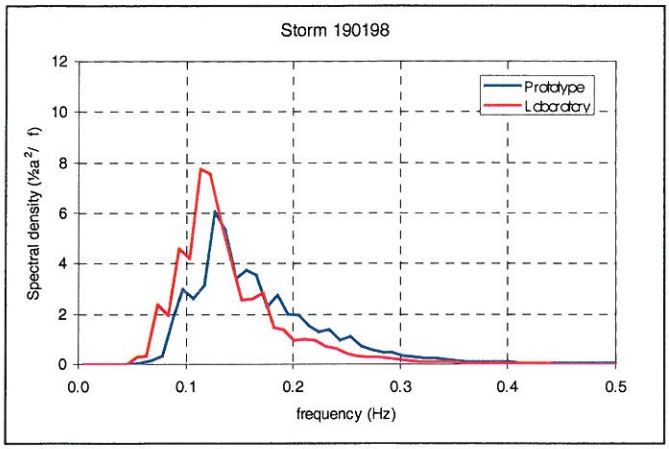


*Figure 5: Spectra from storm 190198.*

The spectra shown in figure 1 to 5 are all total spectra, i.e. the prototype spectra has been obtained without beeing able to determine how much of the energy is incomming and how much is reflection. The spectra from the laboratory is measured at Ze1 and it is naturally impossible to know if the amount of reflection is the same as in zeebrugge.

Given the nature of the phenomena which are modelled, the agreement between prototype and laboratory is satisfactory. It should be possibe to improve the wave generation in labortory, allthough this will entail a considrable amount of work. A comparison between wave parameters are seen in table 1.

| Storm | Prototype | | | | Laboratory | | | |
|---|---|---|---|---|---|---|---|---|
| | $H_{m0}$ | $T_p$ | $T_{01}$ | $H_s$ | $H_{m0}$ | $T_p$ | $T_{01}$ | $H_s$ |
| 070299 | 3.14 | 8.53 | 6.53 | 3.00 | 3.12 | 8.98 | 6.94 | 3.03 |
| 190198 | 2.99 | 8.53 | 6.61 | 2.83 | 2.96 | 8.26 | 7.21 | 2.86 |
| 200198 | 3.08 | 8.53 | 6.58 | 2.87 | 3.00 | 9.14 | 7.23 | 2.88 |
| 2808951 | 2.86 | 7.31 | 6.18 | 2.74 | 2.90 | 7.42 | 6.26 | 2.80 |
| 2808952 | 2.69 | 9.31 | 6.40 | 2.55 | 2.69 | 8.98 | 6.86 | 2.62 |

*Table 1: Comparison of wave conditions.*

### *Run-up results*

Run-up has been measured in two different ways, using the traditional resistance gauge and a new step gauge.

The resistance gauge lacks quality because it does not get close enough to the surface of the breakwater. This is easily seen from the measurements were 2% run-up is 34% higher using the step gauge on average during the five prototype storms.

The step gauge has some measuring problems too which entails that only the height of the run-up peaks are reliable, whereas the "form" of the run-up as well as the run-down is not usable.

By carefully analysing the data it has been possible to get some results eventhough there has been some problems with the measuring devices. Table 2 shows a comparison between prototype and laboratory.

| Storm | Prototype | | Laboratory | | | |
|---|---|---|---|---|---|---|
| | $Ru_{2\%}$ | $Ru_{2\%}/H_{m0}$ | $Ru_{2\%}$ Res. | $Ru_{2\%}$ Max. | $Ru_{2\%}$ Sum. | $Ru_{2\%}/H_{m0}$ |
| 070299 | 5.42 | 1.73 | 4.21 | 5.70 | 5.33 | 1.71 |
| 190198 | 5.09 | 1.73 | 4.08 | 5.40 | 5.21 | 1.76 |
| 200198 | 5.37 | 1.79 | 4.35 | 5.85 | 5.66 | 1.89 |
| 2808951 | 4.27 | 1.49 | 3.04 | 4.72 | 4.40 | 1.52 |
| 2808952 | 4.43 | 1.66 | 3.72 | 5.31 | 5.13 | 1.91 |

*Table 2: Comparison between Run-up measurements in prototype and laboratory. (Res.=Resistance gauge, Max.=Maximum run-up on stepgauge, Sum.=Accumulated run-up on stepgauge).* $Ru_{2\%}/H_{m0}$ *in the laboratory is composed from the Sum. measurement.*

The general conclusion from the prototype storms is that looking at run-up measured with the step-gauge the results are comparable with the prototype measurements. The resistance gauge clearly underestimates the run-up.